Remarks

Reconsideration of this Application is respectfully requested.

Upon entry of the foregoing amendment, claims 2-5, 7, 9, and 10 are pending in the application, with claims 3 and 9 being the independent claims. Claims 12 is sought to be canceled without prejudice to or disclaimer of the subject matter therein. Claims 2-5, 7, 9, and 10 are sought to be amended. These changes are believed to introduce no new matter, and their entry is respectfully requested.

Based on the above amendments and the following remarks, Applicant respectfully requests that the Examiner reconsider all outstanding rejections and that they be withdrawn.

Personal Interview

Applicant and Applicant's representatives wish to thank Examiner Ryan R. Yang for the personal interview with the Applicant's representatives, Mr. Michael V. Messinger and Mr. Timothy A. Doyle, on December 15, 2005.

During the interview, Applicant's representatives explained the present invention and distinguished it from the documents that had been applied by the Examiner based upon, *inter alia*, the lack of sampling, in the present invention, of the set of three-dimensional computer graphics data to be rendered.

Rejections Under 35 U.S.C. § 103

Claims 2-5, 7, 9, 10, and 12 were rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,532,017 to Knittel *et al.* (hereinafter "Knittel") in view of U.S. Patent No. 5,760,781 to Kaufman *et al.* (hereinafter "Kaufman"). (*See* Office Action at ¶ 6.)

Regarding claim 12, Applicant has canceled this claim without prejudice to or disclaimer of the subject matter therein, thereby rendering the rejection of this claim moot.

Regarding claims 2-5, 7, 9, and 10, Applicant respectfully traverses these rejections. Amended independent claim 3 recites (emphasis added):

> A method for presenting three-dimensional computer graphics images of a scene using multiple graphics processing units, comprising the steps of:
>
> (1) allocating, to the multiple graphics processing units, a set of three-dimensional computer graphics data such that said allocated set of three-dimensional computer graphics data corresponds to portions of the scene that lie within rectangular subvolumes to which the multiple graphics processing units have been assigned;
>
> (2) determining a viewing position, ***wherein said determined viewing position determines an aspect of said allocated set of three-dimensional computer graphics data to be rendered;***
>
> (3) communicating said determined viewing position to the multiple graphics processing units;
>
> (4) rendering, by the multiple graphics processing units, said allocated set of three-dimensional computer graphics data;
>
> (5) combining said rendered set of three-dimensional computer graphics data with image combiners, wherein outputs from the multiple graphics processing units are direct inputs to first stage image combiners and outputs from at least two of the first stage image combiners are direct inputs to a second stage image combiner, thereby producing a three-dimensional computer graphics image; and
>
> (6) presenting, for viewing, said combined three-dimensional computer graphics image.

Amended independent claim 9 recites (emphasis added):

> A system for presenting three-dimensional computer graphics images of a scene, comprising:
>
> memory for storing a set of three-dimensional computer graphics data;
>
> multiple graphics processing units for rendering the set of three-dimensional computer graphics data that corresponds to portions of the scene that lie within rectangular subvolumes to which said multiple graphics processing units are assigned;
>
> a bus for communicating a viewing position to each of said multiple graphics processing units, ***wherein the viewing position determines an aspect of the set of three-dimensional computer graphics data to be rendered;*** and
>
> image combiners for combining the set of three-dimensional computer graphics data rendered by said multiple graphics processing units to produce a three-dimensional computer graphics image, wherein outputs from the multiple graphics processing units are direct inputs to first stage image combiners and outputs from at least two of the first stage image combiners are direct inputs to a second stage image combiner.

Support for these amendments can be found at paragraphs 34 and 35 of the specification of the present patent application:

> **[0034]** In FIG. 5, at a step 504, a viewing position is determined. The viewing position controls which aspect of the three-dimensional graphics data will be presented for viewing. FIG. 6 illustrates this point. Item 602 replicates the example scene originally presented in FIG. 1 with the rectangular subvolumes superimposed on it as shown in FIG. 3. FIG. 6 includes two other illustrations that demonstrate how the scene depicted in item 602 would appear from different viewing positions. Item 604 shows one viewing position. Note that from this angle part of the tree is obscured by the image of the rabbit. Item 604 demonstrates another viewing position. Note that from this "birds eye" view that both the tree and the rabbit are visible, but the trunk of the tree and parts of the body of the rabbit are not. The ability to view all aspects of the scene by changing the viewing position is an advantage of the present invention. The viewing position can be determined by the application software either automatically or interactively via a command entered by the user.
>
> **[0035]** In FIG. 5, at a step 506, the viewing position is communicated to each GPU. At a step 508, each GPU renders the graphics data that has been allocated to it. The architecture of the present invention supports the possibility that each GPU could render, by itself, the full image. In one embodiment, pixels rendered include channels representing the primary colors of red, green, and blue and an alpha channel that indicates the degree of

translucence for that pixel. Translucence can range from transparent to opaque.

Neither Knittel nor Kaufman, alone or in combination, discloses, teaches, or suggests using the viewing position to determine an ***aspect*** of the set of three-dimensional computer graphics data to be rendered.

In Knittel, the viewing position determines a ***sample*** of the set of the three-dimensional computer graphics data to be rendered. Knittel at figures 4, 5A, and 5B and at column 9, lines 20-59 recites:

> FIG. **4** illustrates the processing of an individual ray **18**. Ray **18** passes through the three dimensional volume data set **10** at some angle, passing near or possibly through voxel positions **12**, and accumulates at sample points **20** along each ray. The value at each sample point is synthesized as illustrated at **21** by an interpolation unit **104** (see FIG. **5**), and the gradient at each sample point is calculated as illustrated at **23** by a gradient estimation unit **112** (see FIG. **5**). The sample point values from sample point **20** and the gradient **25** for each sample point are then processed to assign color, brightness or intensity, and transparency or opacity to each sample. As illustrated at **27**, this processing is done via pipeline processing in which red, green and blue hues as well as intensity and opacity or transparency are calculated. Finally, the colors, levels of brightness, and transparencies assigned to all of the samples along all of the rays are applied as illustrated at **29** to a compositing unit **124** that mathematically combines the sample values into pixels depicting the resulting image **32** for display on image plane **16**.
>
> The calculation of the color, brightness or intensity, and transparency of sample points **20** is done in two parts. In one part, a function such as trilinear interpolation is utilized to take the weighted average of the values of the eight voxels in a cubic arrangement immediately surrounding the sample point **20**. The resulting average is then used to assign a color and opacity or transparency to the sample point by some transfer function. In the other part of the calculation, the gradient of the sample values at each sample point **20** is estimated by a method such as taking the differences between nearby sample points. It will be appreciated that these two calculations can be implemented in either order or in parallel with each other to produce equivalent results. The gradient is used in a lighting calculation to determine the brightness of the sample point. Lighting calculations are well known in the computer graphics art and are described, for example, in the textbook "Computer Graphics: Principles and Practice," 2nd edition, by J. Foley, A. van Dam, S. Feiner, and J. Hughes, published by Addison Wesley of Reading, Mass., in 1990.

Likewise, in Kaufman, the viewing position determines a ***sample*** of the set of the three-dimensional computer graphics data to be rendered. Kaufman at figure 6 and at column 9, lines 22-26 recites "[a]s shown in FIG. **6**, the ray projection mechanism includes a plurality of input ports **34** for receiving the plurality of interpolated sample signals for each of the plurality of continuous viewing rays." Furthermore, Kaufman at figure 2 and at column 7, lines 48-55 recites:

> [r]eferring . . . to FIG. **3**, the apparatus of the present invention **20** also preferably includes an interpolation mechanism **28** coupled to the 2-D buffers **24**. In a preferred embodiment of the invention, the interpolation device is a tri-linear (TRILIN) interpolation mechanism which receives information about continuous viewing rays that are cast, preferably from the selected viewing position, through the cubic frame buffer **22**.

Also, the Abstract of Kaufman, *inter alia*, recites:

> Viewing rays are cast from the viewing position into a cubic frame buffer and beams of voxels, which are parallel to the face of the cubic frame buffer, are accessed. At evenly spaced sample points along each viewing ray, each sample point is tri-linearly interpolated using values of surrounding voxels. Central differences of voxels around the sample points yield a gradient which is used as a surface normal approximation. Using the gradient and the interpolated sample values, a local shading model is applied and a sample opacity is assigned. Finally, ray samples along the ray are composited into pixel values and provided to a display device to produce an image.

Accordingly, claims 3 and 9 are patentable over Knittel in view of Kaufman. Claims 2, 4, 5, 7, and 10, which depend upon claims 3 or 9, are also patentable over Knittel in view of Kaufman. Therefore, Applicant respectfully requests that the Examiner remove his rejections of claims 2-5, 7, 9, and 10 under 35 U.S.C. § 103(a) and pass these claims to allowance.

Conclusion

All of the stated grounds of rejection have been traversed. Applicant therefore respectfully requests that the Examiner reconsider all presently outstanding rejections and that they be withdrawn. Applicant believes that a full and complete reply has been made to the outstanding Office Action and, as such, the present application is in condition for allowance. If the Examiner believes, for any reason, that personal communication will expedite prosecution of this application, the Examiner is invited to telephone the undersigned at the number provided.

Prompt and favorable consideration of this Amendment and Reply is respectfully requested.

Respectfully submitted,

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